

**University of Washington**  
Applied Physics Lab  
1013 NE 40<sup>th</sup> Street  
Seattle, WA 98105

## **Final Report**

### **The impact of submarine depth, speed sonar systems on Arctic sea-ice draft measurements**

April 21, 2015

Reporting period: Oct 5, 2010- Sept 30, 2014

Prepared for:  
Office of Naval Research  
875 North Randolph Street  
Arlington, VA 22203-1995

Award Number: N00014-11-0128  
<http://nsidc.org/data/g01360.html>

Submitted by:  
Mark Wensnahan  
Applied Physics Lab  
University of Washington  
Seattle , WA 98195  
phone: (206) 685-7912    fax: (206) 543-3521    email: [thinice@apl.washington.edu](mailto:thinice@apl.washington.edu)

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

UNCLASSIFIED

## **LONG-TERM GOALS**

Arctic sea ice thickness is critical to geophysical research into climate change, shipping, biological productivity and other things. The overall goal of this work is to produce a public archive of ice draft data for research. The data is meant to span the largest time range possible and be of the highest possible quality. In addition the data must include detailed and accurate documentation.

## **OBJECTIVES**

This work is meant to produce a report on the impact of submarine speed and depth.

## **APPROACH**

Software will be adapted for processing of older data. Software will also be developed to process the newest available data. Both older and newer data will be processed, declassified and added to a public archive at NSIDC. A regression analysis will be performed on existing data in the archive to determine the impact of boat speed and depth on data quality. A report will be written on this work for inclusion in the public archive. All of the work will be completed by Dr. Mark Wensnahan.

## **WORK COMPLETED**

Work in 2013 under this grant consisted of 4 basic tasks: (a) a regression analysis of the effect of ship depth and speed on mean draft and other statistics, (b) development of software to process both digital and analog data, (c) processing and analysis of data from two cruises in 2011 and (d) beginning processing of older analog data.

### *Regression Analysis*

An analysis of analog data from the National Snow and Ice Data Center (NSIDC) public archive was performed to determine what impact ship depth and speed have on the ice draft data. In the future it is likely that submarines will be traveling at greater depth and higher speeds, potentially degrading the data and introducing bias. A regression analysis of mean draft, draft mode and the standard deviation of the mean as a function of time of year, location, year and ship depth and ship speed was conducted. The analysis showed that there was no dependence of the draft on ship depth and hence no bias was introduced due increased footprint size. Surprisingly there was a statistically significant dependence of draft with speed. This appears to be due to overwriting of the analog charts. It is not clear if these results hold for the digitally-recorded first return data as those data do not include information on speed or depth. It was concluded that a digital recorder which records the entire return pulse would provide the best quality data for now and into the future. A technical report on this matter has been submitted to the NSIDC archive.

## **IMPACT/APPLICATIONS**

Ice thickness data is used for a large variety of research. An obvious example is climate change. Here the length of record is crucial to establish the past climate and how the climate has changed over the last 50 years. At the same time modern data is regularly used to initialise climate models and improve their predictive power. The data is also often used to validate other methods of determining ice thickness, particularly satellite-based measurements.

## **RECOMMENDATIONS FOR FUTURE WORK**

It is imperative that the record of ice thickness be continued into the future. There are two potential prongs to this effort. First, the development of an ice draft data recorder would make it possible to record the ice draft data independent of whatever equipment the US Navy has aboard submarines already for this purpose. At the same time the Navy is developing and deploying a new data recorder that may provide high quality data in the future. One or preferably both of these technologies should be pursued in the near term until it is clear that one or the other provides consistently high quality data.

## **RELATED PROJECTS**

ONR Contract, Arctic Ice-Cap Submarine Top Sounder Recording, N00014 13 C 0208

## **PUBLICATIONS**

Wensnahan, 2013. "Assessing the impact of speed and depth on sea-ice draft data obtained from US Navy submarines." Technical report, National Snow and Ice Data Center.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. <b>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</b>				
1. REPORT DATE (DD-MM-YYYY) 21-04-2015		2. REPORT TYPE Final Technical		3. DATES COVERED (From - To) Oct 5, 2010- Sept 30, 2014
4. TITLE AND SUBTITLE The impact of submarine depth, speed sonar systems on Arctic  Sea-ice draft measurements			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER N00014-11-0128	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Mark Wensnahan			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Washington - Applied Physics Laboratory 4333 Brooklyn Avenue NE Seattle, WA 98105-6613			8. PERFORMING ORGANIZATION REPORT NUMBER  A60120	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Research (ONR 322)  One Liberty Center 875 North Randolph Street, Suite 1425 Arlington, VA 22203-1995			10. SPONSOR/MONITOR'S ACRONYM(S) ONR	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT  Distribution Statement A: Approved for public release; distribution is unlimited.				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT Arctic sea ice thickness is critical to geophysical research into climate change, shipping, biological productivity and other things. The overall goal of this work is to produce a public archive of ice draft data for research. The data is meant to span the largest time range possible and be of the highest possible quality. In addition the data must include detailed and accurate documentation. Work in 2013 under this grant consisted of 4 basic tasks: (a) a regression analysis of the effect of ship depth and speed on mean draft and other statistics, (b) development of software to process both digital and analog data, (c) processing and analysis of data from two cruises in 2011 and (d) beginning processing of older analog data.				
15. SUBJECT TERMS Sea ice thickness, climate change, unclassified, ice draft data				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT  UU	18. NUMBER OF PAGES  4
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified		
				19b. TELEPHONE NUMBER (include area code) 206-543-1261